regions so widely separated, is an interesting problem in distribution.—JULIA W. SNOW, *University of Michigan.*

*** The work upon which the foregoing paper is based was done in the spring of 1898, while the author held a fellowship given to the Botanical Department by Mr. D. M. Ferry, of Detroit.

EXPLANATION OF PLATE VII.

FIG. 1. Portion of a thallus. × 300.

FIG. 2. Thallus in cross section. × 66.

FIG. 3. Section at the center of a young thallus. × 875.

FIG. 4. Section at the margin of a young thallus. × 875.

FIG. 5. Section through the center of an older thallus. × 300.

FIG. 6. Portion of the surface of a disk ten days after removal from glass. × 300.

FIGS. 7, 8. Young thalli developing when attached to glass. × 875.

FIGS. 9–12. Young thalli when not attached to some solid substratum. *Fig. 9*, × 300; *figs. 10–12*, × 875.

FIG. 13. Zoospores. × 875.

FIG. 14. Shape sometimes assumed by zoospores before liberation and occasionally retained after liberation. × 875.

FIG. 15. Zoospores arising directly from germinating zoospores. × 875.

RECENT WORK ON THE LIFE-HISTORY OF THE RHODOPHYCEÆ.

IN Oltmanns' paper upon the life-history of the Rhodophyceæ[1] we have the most recent general expression of opinion on the difficult problems of sexual reproduction and the attendant phenomena of the development of the cystocarp found in this peculiar group of plants. His is the fourth contribution attempting to cover a broad horizon and dealing with the questions in their totality as illustrated throughout the entire class. The three papers that preceded his account were by Bornet and Thuret in 1867, Janczewski in 1876, and Schmitz in 1883.

Of these three papers the first two gave descriptions of the histology and development of the cystocarps of several types, which, for clearness of expression and beauty of illustration, have not been surpassed. One can only express the greatest admiration for the work of Bornet and Thuret, but their investigations, as also those of Janczewski, came before the time of critical cytological study, and consequently

[1] Zur Entwickelungsgeschichte der Florideen. Bot. Zeit. **56**[1]: 99. 1898.

made no attempt to describe the mechanism and place of the sexual act, that is, the fusion of sexual nuclei. Schmitz, however, formulated explicit theories as the result of his studies, and gave to the world an explanation, or rather, a set of explanations, describing several types of morphological structure and a variety of physiological conditions concerned with the sexual organs. His views have been dominant until very recently.

The most striking features of Oltmanns' contribution is the manner in which he has swung away from the complex and frequently obscure theorizing of Schmitz, and presented an explanation comparatively simple in the demands it makes upon the facts, and perfectly in accord with the stand that biology takes as to the essential conditions and characteristics of the sexual act. To appreciate thoroughly Oltmanns' views it is necessary that one should know the peculiarities of the theories of Schmitz, and wherein they departed so radically from certain general conclusions of biological science.

It is not easy to discuss so complex a subject in a few words. The difficulties lie in the fact that the Rhodophyceæ present a number of different structural characters in the sexual apparatus, making possible a variety of physiological conditions. Thus there is scarcely one genus that is exactly like another as to the detailed morphology of the sexual organs, and, indeed, species of the same genus often differ among themselves.

When one considers how little precise cytological work has been done in the group and how much lies before the investigator, the possible complications that the future may present are not conducive to a feeling of security for any theory applied universally or even generally.

There are two general statements of facts upon which all investigators agree: first, that male cells fuse with a receptive female apparatus, the trichogyne; second, that certain cells, termed auxiliary cells in many types, are stimulated by this phenomenon to produce carpospores. However, the auxiliary cells hold very various relationships to the trichogynes, and these eccentricities have caused the difficulties.

In the simplest cases, as for example Nemalion, the cell that bears the trichogyne itself develops the glomerule of spores, and observations have been reported, according to which it appears that the sperm nucleus passes down the trichogyne and fuses with the female sex-nucleus in the swollen region of the cell below. It seems clear that the physiological conditions during the processes of fertilization in

Nemalion are those of the so-called oosporic type of reproduction, and are not essentially different from the state of affairs described for such a type as Coleochæte. The differences between the two forms are concerned with the morphology of the antherozoid and oogonium (the latter, by custom, termed a carpogonium in Nemalion), and not with the physiology of the sexual act.

But excepting Nemalion and certain related forms that for the most part have not been studied in detail, the other groups of red algæ present various peculiarities. A few examples will be sufficient to illustrate these curious conditions.

In certain species of Callithamnion there are two auxiliary cells, each giving rise to a separate and independent favella of spores. The carpogonium with its trichogyne occupies a position between the two auxiliary cells, but is not connected with either. Indeed, the three structures may be separated from one another by a considerable space. How is the stimulus of a sexual act, taking place in the trichogyne or carpogonium, to be transmitted to the auxiliary cells and excite their development into favellæ of spores? Oltmanns reports some critical observations upon this problem which for a long time has been very perplexing, and they will be referred to in another part of this review.

Dudresnaya furnishes the best known and perhaps most striking peculiarities. Here the auxiliary cells are situated upon widely separated filaments or branches of the frond and often far removed from the carpogonia. The fertilized carpogonium puts forth several filaments that grow among the loosely arranged vegetative filaments and come in contact with the auxiliary cells. At such points the two elements fuse so that the cell-contents mingle, and here are developed the glomerules of spores. Where does the sexual act take place in Dudresnaya, at the points of fusion between the filaments and the auxiliary cells, or previously in the carpogonium? If fertilization is accomplished in the trichogyne or carpogonium, what is the meaning of the second act of fusion at the auxiliary cells?

There are also a number of instances reported, from genera that are not closely related to one another, in such families as the Gigartinaceæ and Rhodomelaceæ. In these there is present one auxiliary cell close by the carpogonium, with which the latter structure fuses directly or by means of a connecting tube. What is the significance of this single auxiliary cell, and what are the cytological phenomena concerned with the act of fusion?

The chief peculiarity of Schmitz's views lay in his theory of a double fertilization, applied to such forms as have auxiliary cells with the phenomenon of secondary fusion, and typified in Dudresnaya. There were two sexual acts. The first occurred when the sperm cell fused with the trichogyne and its male nucleus entered the carpogonium; but a second act of fertilization took place when the fertilized carpogonium, or the filaments derived from this structure, fused with an auxiliary cell. The development of filaments from the carpogonium that were to fuse with auxiliary cells was a device by which the male nuclear substances could be distributed to a number of such elements, thus multiplying greatly the effects of the sexual act.

The extent to which the theories of Schmitz were developed and perhaps extended by his followers, on what seems today a very inadequate basis of fact, need not be considered in detail here. The accounts of various members of the Chylocladiaceæ by Hauptfleisch, and Schmitz's own view of the fusion plate of Corallina are illustrations to the point. The first author stated that in the forms studied by him extensive and indiscriminate phenomena of cytoplasmic and nuclear fusion took place involving not only the sexual elements but various vegetative cells. The present writer believes that he showed the mistake of supposing that in *Champia parvula* this very general cytoplasmic fusion in the vicinity of the carpogonium was a sexual act. The presence of a variable number of auxiliary cells, instead of one, the great extent of the cytoplasmic fusion concerned with these elements, and the fact of the presence in the cells of a great many nuclei that appear to maintain complete independence of one another, all indicate that the unusual phenomenon is not a part of the sexual act but may well be related to nutritive functions. As for Corallina, preparations show that the fusion plate results from the partial absorption of the walls between a layer of cells below the trichogynes. The nuclei apparently remain in their respective positions, and the idea of an extensive multiple fertilization must be abandoned. It appears that Oltmanns himself, although very friendly to much of the work of Schmitz, is not willing to admit the probability of these flights of theory, quite lacking the basis of detailed observations, in a field of cytology offering extreme and peculiar difficulties. The absence of good figures is a serious defect in the papers of Schmitz and his pupils, particularly as they dealt with subjects acknowledged to be of great complexity.

Oltmanns' studies have led him to conclusions that may be stated very briefly. There is only one sexual act and that occurs in the carpogonium. The structure derived from the fertilized carpogonium is comparable to the sporophyte generation of higher plants. The plant that bears the sexual organs is the gametophyte. Tetraspores are special forms of reproductive cells that have no fixed place in ontogeny. The fusion of the carpogonium or filaments derived from the carpogonium (sporophytic) with auxiliary cells (gametophytic) is for purposes of nutrition. The sporophyte is dependent upon the gametophyte in a manner analogous to the conditions illustrated by the bryophytes.

Indeed, in certain instances, the sporophyte holds a relationship to the gametophyte closely similar to that of a parasite upon its host. The act of fusion between cells of the sporophyte and the auxiliary cells concerns the cytoplasm alone. In all such instances the sporophytic nuclei remain apart from the nuclei of the gametophyte. They never come together and unite, but rather appear to take up positions somewhat remote from one another. The gametophytic nuclei become less prominent as the cystocarp develops, and finally may be very inconspicuous, or even break down and disappear. The carpospores are developed through the activity of sporophytic nuclei, and these are genetically derived from the fusion nucleus that resulted from the copulation of male and female elements in the carpogonium.

These conclusions of Oltmanns are the results of investigations upon four genera of the red algæ, Dudresnaya, Gloeosiphonia, Callithamnion, and Dasya. The descriptions are clear, and the excellent figures will be greatly appreciated by those who know the difficulties of this field of study. The evidence would be convincing, were it not for the absence of certain critical stages of nuclear fusion and nuclear division. Perhaps it is not fair to expect such exactness and so much detail in this first presentation of Oltmanns' theories, and the presumptions are certainly in favor of the correctness of his explanations. However, someone must complete the chain of evidence before we can consider the proof as absolute.

The account of Callithamnion is perhaps the most interesting contribution in the paper, since it concerns a well known and much studied type. Oltmanns finds that the fertilized carpogonium in *Callithamnion corymbosum* divides into two cells, which extend on each side towards the auxiliary cells. A small cell, cut off from each of these on the side nearest the auxiliary cell, fuses with the latter. A sporophytic nucleus

is thus introduced into both auxiliary cells and divides near the points of entrance. One of these two nuclei passes to the top of each cell, from which region the favella is to develop. The original nucleus (gametophytic) of each auxiliary cell, together with one of the sporophytic nuclei, finally becomes cut off from the developing favella by a wall and takes no further part in the history of the cystocarp. If these observations are confirmed in other species of Callithamnion the fact will be regarded by the writer as one of the most valuable observations that has been published in this field of investigation; for Callithamnion has presented one of the most difficult problems offered to students of the red algæ. Moreover, the physiological conditions there present seem to be duplicated in a number of genera (Spermothamnion, Griffithsia Lejolisia, etc.). A satisfactory explanation for Callithamnion offers the hope that we may finally understand the complicated organization in a number of other forms.

Time alone will determine how generally the theory of Oltmanns may be applied. The instances of detailed observations on the puzzling conditions of this remarkable group of plants are so few, in comparison to the mass of perplexing phenomena presented, that one may well hesitate before considering Oltmanns' views as established. But it appears to the writer that Oltmanns gives us the most reasonable theory yet presented *in extenso*, the most satisfactory working hypothesis for future investigation, and that its stimulus upon research in this group of algæ will be far reaching.—BRADLEY MOORE DAVIS, *The University of Chicago.*

A NEW SILPHIUM.

IN describing a new Silphium as *S. lanceolatum* in the February number of the BOTANICAL GAZETTE (p. 139) I unaccountably overlooked the fact that Nuttall had used the same specific name in the genus. I therefore propose the name of *Silphium Chickamaugense* for this species.—WM. M. CANBY, *Wilmington, Del.*